OBSERVATIONS ON *LOXOCYTHERE (LOXOCYTHERE) OUYENENSIS* (CHAPMAN, 1914) (OSTRACODA) FROM THE CENOZOIC OF S.E. AUSTRALIA WITH COMMENTS ON SPECIES ATTRIBUTED TO *MICROCYTHERURA* MÜLLER, 1894 AND *HEMIPARVOCYTHERE* HARTMANN, 1982 FROM AUSTRALIAN AND NEW ZEALAND MARINE WATERS.

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The type material of *Loxocythere (Loxocythere) ouyenensis* (Chapman, 1914) from mid Cenozoic strata of the Mallee Bore No. 11 in the Murray Basin, S.E. Australia is partially redescribed and refigured. This species belongs to a discrete group of large elongate Cenozoic fossil and living *Loxocythere* species, the carapaces of which possess sub-rectangular inner margin outlines, and broadly rounded posterior extremities. Some much smaller but otherwise very similarly shaped species, that have previously been placed under the genus *Microcytherura* (i.e. *Microcytherura? peterroyi* Yassini and Jones, 1995) or the genus *Hemiparvocythere* Hartmann, 1982 (i.e. *Hemiparvocythere lagunicola* Hartmann, 1982), are also known from marine Cenozoic strata and modern seas of the Australasian region. There is a marked difference in the shape of the inner margin between this group of small Australasian forms and European species of *Microcytherura s.s.*. The former have broadly rounded posterior inner margins, whilst the latter have acutely rounded posterior inner margins. The latter also usually present posterior extremities located well below mid carapace height. It is here argued that this difference in inner margin shape between smaller Australasian species such as *Microcytherura? peterroyi*, and European species of *Microcytherura s. s.*, suggests that there is not a direct phylogenetic relationship between these two species groups.

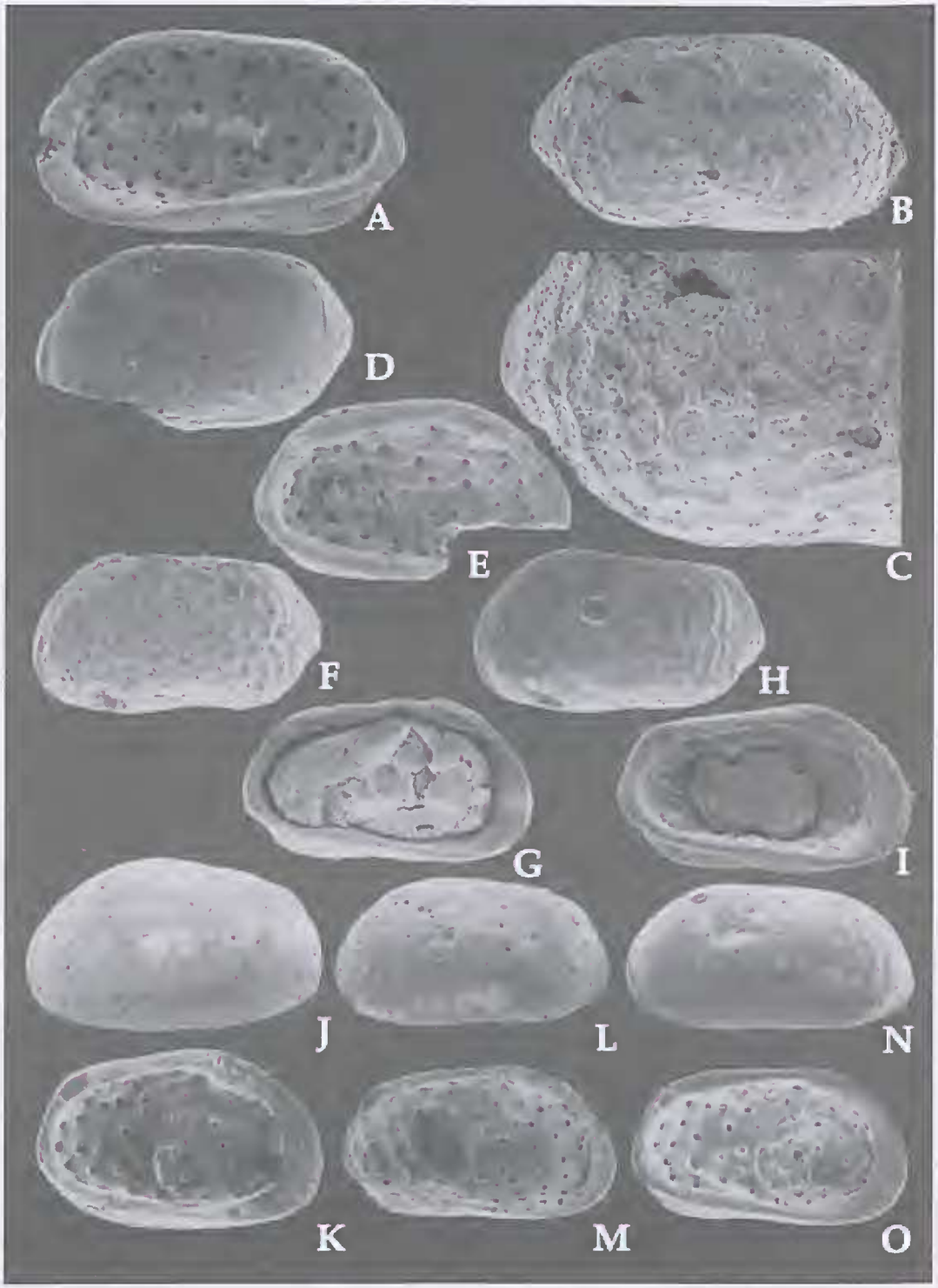
Key words: Ostracoda, *Loxocythere (Loxocythere) ouyenensis*, *Microcytherura*, *Hemiparvocythere*, Cenozoic, Australia, New Zealand

A VARIETY of species groups attributed to the genera *Loxocythere* Hornibrook, 1952 or *Microcytherura* Müller, 1894 have existed in Australasian marine waters throughout the Cenozoic and into the modern day. Previously, larger species have generally been assigned to the genus *Loxocythere* and smaller species to the genus *Microcytherura* (see also discussion in Warne, 2004). This paper will firstly describe the various species groups of the genus / subgenus *Loxocythere (Loxocythere)*. Secondly, the phylogenetic relationship between some elongate *Loxocythere (Loxocythere)* species and some similarly shaped but smaller Australasian species, variously attributed to the genera *Microcytherura* and *Hemiparvocythere* Hartmann, 1982, will be discussed. Thirdly, the type material of species *Loxocythere (Loxocythere) ouyenensis* (Chapman, 1914) will be reviewed. Specimens illustrated herein are housed in Museum Victoria and have the registration numbers, P12529, P122297, P311646 - P311652.

COMPARATIVE MORPHOLOGY

Loxocythere (Loxocythere) Hornibrook, 1952

There are three types or groups of species here recognised under the genus / subgenus *Loxocythere (Loxocythere)*. The first, is the *Loxocythere* type species *L. (L.) crassa* Hornibrook, 1952, which has a thick shell, rugged reticulate ornament, subquadrate shaped inner margin and posterior extremity below mid height. The second group, which includes *L. (L.) kingi* Hornibrook, 1952 and *L. (L.) variasculpta* Whatley *et. al.*, 1997, have subdued ornament, relatively elon-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gate subrectangular carapaees / inner margins, and aeutely rounded posterior outlines with valve posterior extremities well below mid height. The third group ineludes the species *L.(L.) hornibrooki* McKenzie, 1967 , *L.(L.) ouyenensis* (Chapman, 1914), *L. (L.) inflata* Hanai, 1959 and *L. (L.)* sp. (this study), whieh also have relatively elongate subreetangular earapaees and inner margin outlines, but differ from other groups of *Loxocythere (Loxocythere)* speeies by possessing broadly rounded posterior extremities. This group of speeies is transitional in earapaee morphology between *Loxocythere (L.) crassa* and speeies of the genus *Cythere* O. F. Müller, 1785 (see Hanai, 1959, p. 414-415; plate 28). Thus, *Loxocythere (Loxocythere)* speeies in groups two and three ean be distinguished from *L. (L.) crassa* by possessing relatively elongate carapaees. Further, *Loxocythere (Loxocythere)* speeies in groups two and three can be distinguished from each other by differences in the shape of the posterior inner margin. These speeies groups are not designated as separate subgenera beeause the earapace shape differenees that are used here to delineate speeies groups are rather gradational in nature. Speeies of *Loxocythere (Novoloxocythere)* Warne, 2004 ean be elearly distinguished from *Loxocythere (Loxocythere)* spp. as the former possesses posterior extremities well above mid height (i.e. adjaeent to the dorsal margin).

The speeies *L. (L.) crassa* is only known from the New Zealand region. Speeies in *Loxocythere (Loxocythere)* group two have been variously reeorded from shallow marine waters or sedimentary facies of the New Zealand and Antaretic regions, and from the south-west Atlantic continental shelf. Speeies in *Loxocythere (Loxocythere)* group three are known from the western Pacific region, eurrent records being from eoastal Australasia and Japan.

Microcytherura G. W. Müller, 1894

The genus *Microcytherura* was originally established to aeeommodate European ostracod speeimens with *Microcytherura nigrescens* G. W. Müller, 1894 being designated as the type speeies. A distinctive earapaee eharaeteristie of this speeies and other European species of *Microcytherura* sueh as *M. fulva* (Brady and Robertson, 1874) and *M. angulosa* (Seguenza 1880), is a strong oblique dorsal truneation of the posterior margin (see fig 2 A-D). These delieately ornamented speeies possess posterior extremities near or below mid earapace height and possess an aeutely rounded and elongated posterior margin with a relatively small angle between a short posteroventral margin and longer posterodorsal margin. Speeies with this type of posterior earapaee shape and delieate earapaee surfaee ornament oeeur in European and nearby seas, and ean be considered as one distinetive speeies group within the genus *Microcytherura*. One Australian speeies, *Microcytherura sulcata* Yassini and Jones, 1995, is similar in general shape to European *Microcytherura* spp., although differs by possessing a strongly ornamented earapaee. In general shape and ornament *M. sulcata* resembles various west Afriean speeies sueh as *Microcytherura reticulata* Hartmann, 1974 and *Microcytherura ornata* Jellinek, 1993. These three Australian / west Afriean speeies make up a seeond, very distinctive group of speeies, within the genus *Microcytherura*. On the basis of similarities in earapaee shape (in partieular the preseneee of aeutely rounded posteriors) these two *Microcytherura* species groups as outlined above are here eonsidered to have a elose phylogenetic relationship.

Within Australian shallow marine environments there is a diversity of eytherid "speeies groups" that have been attributed to the genus *Microcytherura*. Aside from *M. sulcata*, few of the speeies in these groups have posterior earapaee or inner margin shapes akin to those of European (or west Afriean) *Microcytherura* speeies. One of these species groups, which ineludes the speeies *Microcytherura? peterroyi*

Fig. 1. A – C. *Loxocythere (Loxocythere) ouyenensis* (Chapman, 1914). Holotype, right valve, adult, male(?), P12529, from Mallee No.11 bore (267-270 feet), mid Cenozoic. A. Internal view, x 100. B. External view, x 100. C. External view of ornament in posteroventral region of earapace, x 200. D – E. *Loxocythere (Loxocythere)* sp. Left valve, adult, female(?), P311652, from Nepean 1 borehole (178.3 m), late Late Miocene. D. External view, x 100. E. Internal view, x 100. F – G. *Loxocythere (Loxocythere) ouyenensis* (Chapman, 1914). Left valve, juvenile, male, P311646, nodule bed at base of Sandringham Sand (Black Rock Sandstone) outeropping on sea bed 30 metres offshore from a point on the beach at the base of coastal cliffs between the Beaumaris Motor Yacht Squadron and the old Keefer's Boathouse, Beaumaris, Victoria, latest Miocene or earliest Pliocene. F. External view, x 100. G. Internal view, x 100. H – I. *Loxocythere (Loxocythere) ouyenensis* (Chapman, 1914). Left valve, juvenile, female, P122297, from Koo-wee-rup 14 (87– 113 m), early Middle Miocene. H. External view, x 100. I. Internal view, x 100. J – K. *Microcytherura?* sp. Left valve, adult, female, P311647, from Sherwood 18 (20m – 22 m), late Late Miocene. J. External view, x 100. K. Internal view, x 100. L – M. *Microcytherura?* sp. Left valve, adult, male, P311648, from Sherwood 18 (20m – 22 m), late Late Miocene. L. External view, x 100. M. Internal view, x 100. N – O. *Microcytherura?* sp. Left valve, adult, male, P311649, from Nepean 1 (178.3m), late Late Miocene. N. External view, x 100. O. Internal view, x 100.

Yassini and Jones, 1995, *Microcytherura? aestuaricola* Hartmann, 1980, *Microcytherura? triebeli* McKenzie, 1967 and *Microcytherura?* sp. (this study, Figs. 1J-O), possess broadly rounded posteriors with posterior extremities around (or slightly above / below) mid height. These posterior carapace shape characteristics are in contrast to those of European *Microcytherura* species, but are very similar to the posterior outlines of some (larger) species belonging to the genus *Loxocythere (Loxocythere)* such as *L. (L.) onyenensis* (see Plates 1 & 2). It is here argued that the difference in inner margin shape between this group of Australasian "*Microcytherura*" species (with broadly rounded posterior margins), and species of *Microcytherura s.s.*, (i.e. European forms), suggests that there is not a direct phylogenetic relationship between these two species groups. Australasian species, such as *Microcytherura? peterroyi,* are herein thought to have evolved from ancestral stock allied to elongate *Loxocythere (Loxocythere)* species such as *L. (L.) onyenensis* and as a result, considered examples of evolutionary modifications related to changes in carapace size. As a consequence, the genus *Micro-cytherura*, as it is generally and broadly applied to both European and Australian ostracod faunas, appears to be a polyphyletic taxon. However, if only applied to the European species (i.e. *M. nigrescens*, *M. fulva* and *M. angulosa*), as well as perhaps Australian and west African species such as *M. sulcata*, this genus may represent a monophyletic cluster of species. The latter taxonomic framework is here considered preferable, although a full taxonomic review of Australian "*Microcytherura*" species is beyond the scope of this paper.

As illustrated here, particularly significant morphological similarities occur between juvenile valves of *Loxocythere (Loxocythere) onyenensis* (i.e. Figs. 1 F - I) and adult specimens of the Australian taxon *Microcytherura?* sp. (Figs. 1J - O), although the latter tend to have slightly lower and less conspicuously caudate posterior extremities (just below mid-height). This observation suggests that paedomorphic processes, initially operating in *Loxocythere* "ancestral stock", may have contributed to the radiation and diversification of some smaller Australian Cenozoic groups of so-called *Microcytherura* species.

Hemiparvocythere Hartmann, 1980

Some very small Australasian species belonging to the family Parvocytheridae Hartmann, 1959 (for example *Hemiparvocythere lagunicola* Hartmann, 1982), are also similar in carapace morphology to larger Australian Cenozoic *Loxocythere (Loxocythere)* species, although there are marked differences in the soft part anatomy. In the Parvocytheridae, there is a reduction from three walking appendages (maxilla and two thoracic legs) to only two (maxilla and one thoracic leg) reflecting adaptation to an interstitial environment (Hartmann and Puri, 1974). Despite this substantial difference in soft part anatomy, Hartmann and Puri (1974) commented that there is a close phylogenetic relationship between the Cytheridae

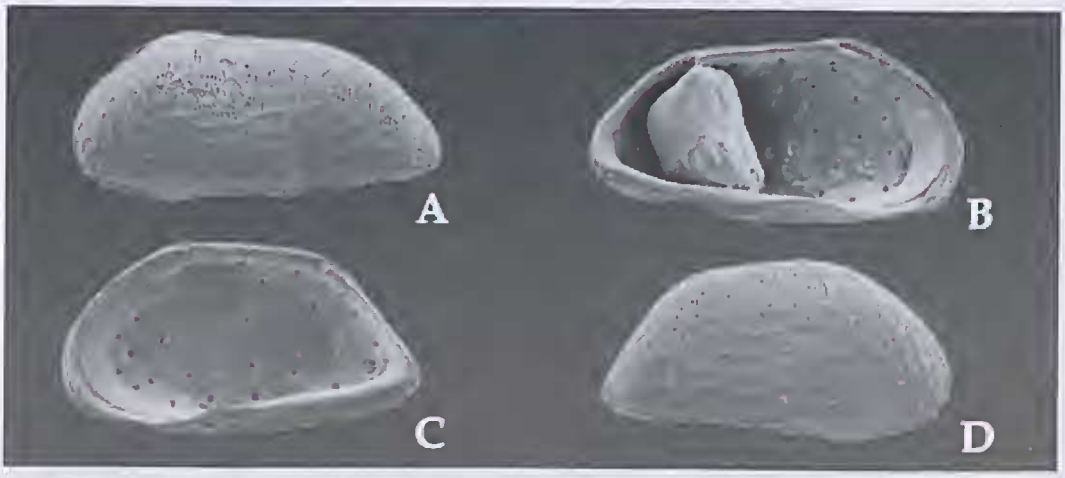

Fig. 2. Microcytherura angulosa (Seguenza, 1880) Specimens are from the seabed of the Adriatic Sea, Recent. A. Left valve, male, external view, P311650, x 100. B. Left valve, male, internal view, P311650, x100. C. Right valve, female, internal view, P311651, x 100. D. Right valve, female, external view, P311651, x 100.

Baird, 1850 and Parvocytheridae, the latter probably being derived from the former. The implication from this analysis by Hartmann and Puri (1974) is that close phylogenetic relationships are not always completely reflected in soft part anatomy, but rather may be more obvious in morphologically conservative carapace characters.

SYSTEMATIC PALAEONTOLOGY

Subclass Ostracoda Latreille, 1806
Order Podocopida G.W. Müller, 1894
Suborder Podocopina Sars, 1866
Superfamily Cytheracea Baird, 1850
Family Cytheridae Baird, 1850
Subfamily Cytherinae Baird, 1850

Remarks: Most authors place the genus *Microcytherura s.s.* (European species') within the Cytheridae Baird (i.e. Jellinek, 1993), although as discussed by van Morkhoven, 1963, there is good evidence for the genus being placed within the Cytheruridae Müller, 1894. The latter view brings into question the often assumed close taxonomic relationship between *Loxocythere* and *Microcytherura* (i.e. Howe and McKenzie, 1989; Hartmann, 1982; McKenzie *et. al.*, 1993; Yassini and Jones, 1995). This controversy is not here resolved. However it is the view of the present author that European species of *Microcytherura* are congeneric with the more robustly ornamented west African species *M. reticulata* and *M. ornata,* and one Australian species, *M. sulcata.* Members of this ornate group of *Microcytherura* species, and the European species *Microcytherura angulosa,* (Seguenza, 1880) bear a close resemblance in inner margin outline to the New Zealand species *Loxocythere (Loxocythere) kingi.* All these species have a relatively elongated carapace posterior that is acutely rounded, the extremity of which is positioned adjacent to, or near, the ventral margin. This observation suggests that a common family level taxonomic association is warranted for the genera *Microcytherura* and *Loxocythere.*

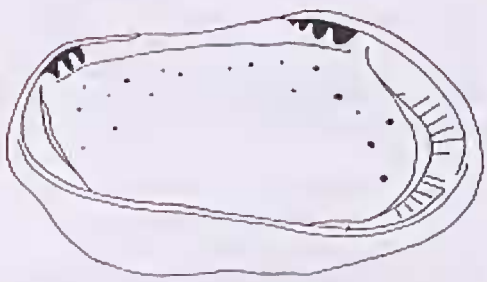

Fig. 3 *Loxocythere (Loxocythere) ouyenensis* Chapman, 1914; line drawing, left valve, juvenile, female(?), internal view, P122297, from Koo-wee-rup 14 (87– 113 m), early Middle Miocene, x 150.

Whilst most Cytherinae species possess a relatively simple merodont (hemimerodont or antimerodont) hinge, some species such as *Loxocythere (L.) crassa* Hornibrook, 1952 have pentodont – like terminal thickenings of the medium hinge element (pseudopentodont hinge sensu Warne, 1996; see Hartmann 1982, Pl. 1, figs. 7 & 8). A pseudopentodont hinge is also apparent in the species *Microcytherura angulosa* (figs. 2B and 2C herein; see also Bonaduce et. al., 1975, Pl. 46, figs 4 -6). However, for these two species, this medium hinge feature is associated with typically crenulated or lobed, and overall subrectangular shaped cytherine posterior hinge elements, and not with the generally smooth, rounded or arched posterior hinge elements characteristic of the true pentodont hinges; the latter as usually found in leptocytherid species belonging to the subfamily Pectocytherinae Hanai, 1957. Similarly, the parvocytherid *Hemiparvocythere lagunicola* Hartmann, 1982 also displays terminal thickening of the medium hinge element (Hartmann, 1982; Plate 5, figures, 4 & 5).

Genus **Loxocythere** Hornibrook, 1952
Subgenus **Loxocythere** Hornibrook, 1952
Type species, *Loxocythere crassa* Hornibrook, 1952

Remarks: Prior to the present study, a number of taxonomic schemes had been proposed for the genera *Microcytherura* Müller, 1894, *Tetracytherura* Ruggieri, 1952 and *Loxocythere* Hornibrook, 1952. Ruggieri (1959) and Hanai (1957) regarded *Tetracytherura* [type species = *M. angulosa* (Seguenza, 1880)] as a junior synonym of *Loxocythere* while van Morkhoven (1963) and Hartmann (1979) regarded *Tetracytherura* as a junior synonym of *Microcytherura.* McKenzie (1967) and Bonaduce *et. al.* (1975) maintained it as a separate genus. Whilst the type species of the genus *Tetracytherura* is much less elongate than the type species of *Microcytherura,* it is here considered that this morphology difference is insufficient in extent to recognise two separate gen-

era. Hartmann (1980) considered *Loxocythere* a subgenus of *Microcytherura*, with *Microcytherura (Microcytherura)* being smaller and possessing only one type of normal pore canal, and *Microcytherura (Loxocythere)* being relatively large and possessing three types of normal pore canal. However, given the problematic family level taxonomic relationship between *Microcytherura* and *Loxocythere* (see above discussion) it would seem appropriate for the present to regard both as discrete genera. Some European loxoconchid species, such as *Elofsonia baltica* (Hirschmann), are convergent in carapace morphology towards some elongate *Loxocythere* species, although the former are generally thin shelled and less ventrally inflated.

Loxocythere (Loxocythere) onyenensis
(Chapman, 1914)
Figs. 1A-C, F-I; 3.

1914 *Cytherura onyenensis* Chapman, p. 44 -45, pl.8, figs. 35a,b
1916 *Cytherura onyenensis* Chapman, p. 379, pl. 74, figs. 35a & b
1981 *Loxocythere onyenensis* Chapman, McKenzie, p. 106.
1987 *Loxocythere* sp.6 Warne, p.441.

Holotype: Adult, right valve, P12529

Type Locality: Mallee Bore 11 at 267 -270 feet (see Chapman 1914 for further details)

Material. The type specimen is from subsurface mid Cenozoic marls of the Murray Basin, Victoria, Australia (Fig. 1 A-C). Additional, mostly juvenile specimens examined for this study come from mid Miocene and Late Miocene shallow marine sand facies of the Port Phillip and Western Port Basins (Figs. 1F-I;3). Details of localities in the Port Phillip Basin and the Western Port Basin that are listed in the figure captions can be found in Warne, 1993 and 2002.

Additional description: The following comments are modifications or expansions of descriptive comments provided by Chapman, 1914 (p. 44 - 45). Carapace large, elongate, subrectangular and thick shelled with a faint, reticulate ornament (varies in strength between specimens). Carapace with posteroventral inflation that slightly overhangs the posteroventral margin. Posterior extremity of RV at about mid-height and slightly caudate; anterior extremity slightly below mid height. In RV maximum height anterior of mid length. Adductor muscle scar pattern consisting of a vertical row of four individual oblong scars. Inner margin well calcified in both adult and juvenile specimens. Normal pore canals numerous and very large, particularly as viewed from an internal perspective. Hinge is merodont with a smooth median element and laterally elongate and strongly crenulated terminal hinge elements.

Dimensions: Holotype, right valve, adult, P12529, length = 0.55 mm, height = 0.29 mm

Remarks: The dimensions of the holotype of *Loxocythere (Loxocythere) onyenensis* recorded here are less than those recorded by Chapman, 1914. The Pleistocene S. E. Australian species *Loxocythere (L.) posteventrobullata* McKenzie, *et. al.*, 1990 differs from *L.(L.) onyenensis* only by possessing a slightly more inflated posteroventral margin; the former being a closely related descendant, or junior synonym of the latter. The latest Miocene S.E. Australian species *Loxocythere (Loxocythere)* sp. (Fig. 1 D – E) differs by possessing a smooth carapace (except for very faint reticulation in posterior third of carapace) and a greater height to length ratio.

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